Effects of Potassium and Sodium Chloride levels in finishing diets on Growth Performance, Serum Electrolyte Levels, and Carcass Characteristics of Beef Finishing Cattle

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ABSTRACT

An experiment was conducted to evaluate the effects of different levels of potassium (K) and sodium chloride (NaCl) in feedlot diets. Three hundred seventy-two British by continental cross steers and 97 British by continental cross heifers were stratified by weight, and placed in 32 pens. Pens within weight strata were randomly assigned to one of four treatments in the feedlot facilities of Eastern Colorado Research Center (ECRC). Treatments consisted of 0.63 and 0.99 % potassium (K) in combination with supplemented (0.32% DM), and unsupplemented (0.1%) NaCl in diet DM. A 2x2 factorial arrangement was used to evaluate growth performance, serum electrolyte concentration, carcass characteristics and pen surface nutrient content. Dry matter intake tended (P=0.15) to decrease as K level increased. A tendency (P=0.11) for decreased ADG was observed as K level was increased. Serum electrolyte concentrations were not affected by treatment (P > 0.05). There was a positive trend (P=0.14) for percentage of carcasses grading choice or better with increased Na supplementation. Pen surface electrical conductivity increased (P<0.01) as Na supplemental level increased.

Key Words: Potassium, Sodium Chloride, Finishing cattle.

INTRODUCTION

There are increasing environmental concerns regarding manure disposal from feedlot operations. Manure Na might increase the risks of soil salinity, and sodicity when high sodium level manure is applied to fields (Shainberg, 1996). High levels of potassium in manure applications have increased the risk of hypomagnesaemia in lactating cattle grazing those fields, by lowering Mg concentration in forages (Lighter et al., 1983), and Mg ruminal absorption (Jacobson et al., 1972; Underwood and Shuttle, 1999). Both NaCl, and K are widely used in finishing diet formulations, with levels of 0.3% DM for NaCl, and levels from 0.6 to 0.8% for supplemental K. The recommended ration levels of K for beef finishing cattle is defined for the current NRC as no more than 0.55 % DM (NRC, 1996), while the recommended level is from 0.06 to 0.08 % DM for Na. The general response of increase in water intake with NaCl supplementation has been used in attempts to manipulate rumen function, and in prevention of urinary calculi.

In calves recently shipped, a significant reduction of mortality was observed with supplemental K levels of 1.3 and 2.2% DM diets compared with 0.7 and 3.2% K DM diets (Hutchetson et al., 1984). In contrast dietary levels of K above 0.77 % DM did not significantly affect performance in feedlot steers (Doran et al., 1986). Growth performance was also unaffected in feedlot cattle fed equal to or higher levels of NaCl compared to NRC (Wilson et al., 2004, Flatt et al., 2003). In addition, increasing levels of Na and K in feedlot diets, has been reported to negatively impact weight gain of feedlot lambs (Jackson et al., 1971), and steers (Kunkle et al., 1985).

The objective of the present trial was to evaluate the effects of two supplemental levels of K in combination with two levels of NaCl diets on cattle performance, serum electrolytes level, carcass characteristics, and pen surface nutrient content.

MATERIALS AND METHODS

Three hundred seventy two British by continental cross steers and 97 British by continental cross heifers were housed for 113 and 140 d at the Eastern Colorado Research Center (ECRC) feedlot near Akron, CO starting November 27, 2002.

A 2x2 factorial arrangement was used to evaluate growth performance, serum electrolyte concentration and carcass characteristics. Treatments consisted of 0.63, and 0.99% K, and 0.1 and 0.32% NaCl in diet DM. There were 2 pens of heifers per treatment, with 12 to 13 head per pen, four pens of steers per treatment with 9 to 13 steers per pen, and two pens per treatment with 25 to 28 steers per pen. Cattle were adapted to the finishing diet for 35 d by replacing forage for dry rolled corn (Table 1). Sodium chloride and K were added as part of the supplement (Table 2). Steers and heifers were implanted with Revalor IS® and Revalor IH® respectively; and vaccinated with Bovishield® on d 1. On d 99, cattle in the lightest average BW were re-implanted using Revalor IS®, and Revalor IH®, for steers and heifers respectively. Cattle in the heavier replication were not reimplanted.

Cattle were weighed twice at the beginning of the experiment (November 25, and 26, 2002), and twice at the end of the trial (March 18, and 19, and April 14, and 15, 2003). Unshrunk weights were taken every 28 d at approximately the same time of day, in the morning, before being fed. Cattle were fed once daily in the morning allowing ad-libitum access to the feed. Jugular blood samples were obtained on d 99 from three randomly selected cattle per pen from 20 pens. Blood samples were cooled and centrifuged at 1300-x g for 20 min in an IEC Centra –GP8 centrifuge. Serum was removed and stored in plastic vials and frozen at –20°C until analysis could be performed. Serum

Na, Cl, K and, Mg levels were determined using an ion selective electrode, dilution method using a Roche Hitachi 917 analyzer. On days 114, and 141 cattle were shipped to Fort Morgan (CO), and harvested at Excel beef slaughter facility. Carcass data were recorded by USDA graders. At the end of the trial, five pen surface core samples were obtained from 24 pens, and analyzed for nutrient content at the Soil, Water and Plant Testing Laboratory at CSU.

Statistical Analysis. Growth performance, serum electrolyte concentration, carcass characteristics, and pen surface nutrient content were analyzed using the mixed model of SAS. Class statement included block, sex, and Na and K supplemental levels in the diets. Model statement accounted for the variation in initial BW, and the interactions among class variables. Since there were no gender by treatment interactions, the analysis was performed without inclusion of gender in the model statement, and results reflect the pooled data from both sexes. Means separation was performed using least significant means. Data from one heifer fed the 0.32% NaCl and 0.63% supplemental K treatment was excluded due to detection of pregnancy.

RESULTS AND DISCUSSION

Interactions among Na, K and sex were not significant ($P>0.05$). Heifers had a lighter final weight ($P=0.06$), lower ADG ($P=0.02$), and higher YG ($P=0.009$) than steers. A tendency ($P=0.14$) to increase the percent of carcass grading choice or better was observed as Na level increased. These results are in agreement with the previous research (Spears and Harvey, 1987, Kunkle et al., 1985), however, it is in contradiction with the detrimental effects reported in whether lambs (Jackson et al., 1971). Increased K level tended to have a negative effect on DMI ($P=0.15$), and ADG ($P=0.11$). There were no effects of levels of Na and K, or their interactions, on plasma levels of Mg, K or Na. Electrical conductivity of pen surface samples was increased ($P<0.01$) by Na supplemental in the diets (Table 4).

IMPLICATIONS

Supplemental levels of Na at the levels used in this trial did not affect feedlot cattle performance, reinforcing the concept that Na supplementation is not necessary in finishing diets. Further research should be conducted to evaluate the reasons of the observed decrease in DMI and ADG on the higher K levels diet. The increase in pen surface electrical conductivity in response to NaCl addition to the ration should be addressed in consideration with the risk in increasing salinity in soils where manure would be used for field application.

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Table 1. Rations composition (%dry matter).

Item	Ration 1	Ration 2	Ration 3	Ration 4
Dry Rolled Corn	57	65.7	74.2	81
Alfalfa hay	33	21.8	15.2	7.4
Sunflower Meal	5	5.3	4.4	4.8
Protein Supplement	5	7.2	6.2	6.8
Days Fed	7	14	14	105

Table 2. Supplement ingredients.

	Salt + 0.99 K	Salt + 0.63 K	0.99 K	0.63 K
Wheat Middlings	40.21	50.27	43.73	48.09
Urea	15.82	15.01	15.88	15.96
Salt	3.46	3.50	0.00	3.72
Calcium Carbonate	17.49	17.67	17.48	18.79
Potassium Chloride	10.03	0.00	9.96	0.00
Vitamin E	0.03	0.03	0.03	0.03
Tylan 40	0.16	0.16	0.16	0.17
Bin Aide	0.21	0.20	0.21	0.21
Rumensin 80G	0.22	0.23	0.23	0.24
Vitamin A	0.01	0.01	0.01	0.01
Grain Screenings	9.59	10.00	9.63	9.67
Ammonium Sulfate	2.24	2.34	2.15	2.49
Beef TM	0.13	0.06	0.06	0.07
Selenium 20X	0.04	0.04	0.04	0.04
Copper Sulfate	0.03	0.04	0.04	0.05
Zinc Sulfate	0.00	0.04	0.04	0.04
Manganese Sulfate	0.07	0.11	0.10	0.11
Niacin	0.15	0.16	0.15	0.17
Iron Sulfate	0.11	0.14	0.11	0.14

Table 3. Effects of dietary.K and NaCl levels (%) on growth performance, carcass characteristics and serum

Item	0.1 NaCl		0.32 NaCl			P Values		
	0.63 K	0.99 K	0.63 K	0.99 K	SEM	Na*K	Na	K
Initial Weight, lbs.	722	739	733	764	35.85	0.72	0.25	0.38
Final Weight, lbs.	1203	1203	1210	1188	12	0.23	0.71	0.26
DMI lbs/d	18.99*	18.70	18.81	18.04*	0.40	0.5	0.25	0.15
ADG, lbs/d	3.43[a]	3.41[a]	3.47[ab]	3.27[ac]	0.09	0.18	0.50	0.11
F/G	5.57	5.50	5.64	5.50	0.13	0.71	0.72	0.30
Dressing %	60.1	60.3	60.5	59.9	0.30	0.15	0.95	0.52
Hot CW lbs	722	728	730	716	7.0	0.14	0.77	0.53
YG	2.32	2.19	2.26	2.18	0.07	0.71	0.61	0.17
Choice or better	0.51	0.53	0.58	0.63	0.05	0.76	0.14	0.49
Serum Mg meq/l	2.25	2.24	2.16	2.22	0.05	0.53	0.56	0.36
Serum Na meq/l	142.8	141.38	142.76	141.71	1.16	0.88	0.30	0.90
Serum K meq/l	4.86	4.62	4.89	4.94	0.13	0.34	0.48	0.22
Serum Cl meq/l	98.44	98.58	98.41	98.57	0.70	0.99	0.98	0.83

electrolytes.

[a,b,c] Means within a row with unlike differ (P<0.05).

* Means within a row differ (P<0.10).

Table4. Effects of dietary K and NaCl levels (%) on pen surface nutrient content

Item	0.1 NaCl		0.32 NaCl			P Values		
	0.63 K	0.99 K	0.63 K	0.99 K	SEM	Na*K	Na	K
pH	7.18	7.09	6.97	7.10	0.13	0.41	0.43	0.86
Electrical conductivity	23.58[a]	26.22[b]	27.93[b]	28.01[b]	0.76	0.11	0.10	0.001
Nitrogen (NO3)	8.12	9.55	8.54	10.42	0.93	0.81	0.49	0.10
Phosphorous	412.8	397.71	398.68	401.81	9.34	0.33	0.59	0.52
Potassium	13357	13736	13351	14101	513	0.66	0.67	0.20
Zn	80.69	82.94	76.54	88.41	5.78	0.37	0.90	0.20
Fe	518.7	533.94*	496.62	447.15*	30.08	0.30	0.09	0.58
Mn	32.05	30.34	32.43	31.03	2.41	0.94	0.81	0.51
Cu	14.4	13.86	16.68	18.24	1.79	0.56	0.08	0.78

[a,b,c] Means within a row with unlike differ (P<0.05).

* Means within a row differ (P<0.10).